

Impact of novel defect reduction hardware on EUV patterning defectivity

2014 International symposium on Extreme Ultraviolet Lithography

Tokyo Electron Kyushu Ltd. / SPE process dept.

Y. Kuwahara, K. Matsunaga, K. Nafus, S. Kawakami

imec

P. Foubert, J. Hermans, E. Hendrickx, A-M. Goethals



TOKYO ELECTRON

imec

Contents

- **Introduction**
- **Experimental result**
 - Defect reduction for L/S pattern by improved resist dispense system
 - Blanket coating defectivity
 - Post litho defectivity
 - Post etch defectivity
 - Pattern collapse mitigation
- **Summary**

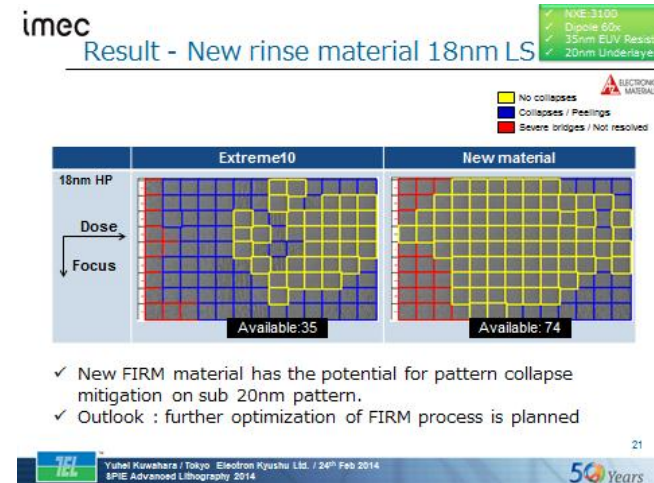
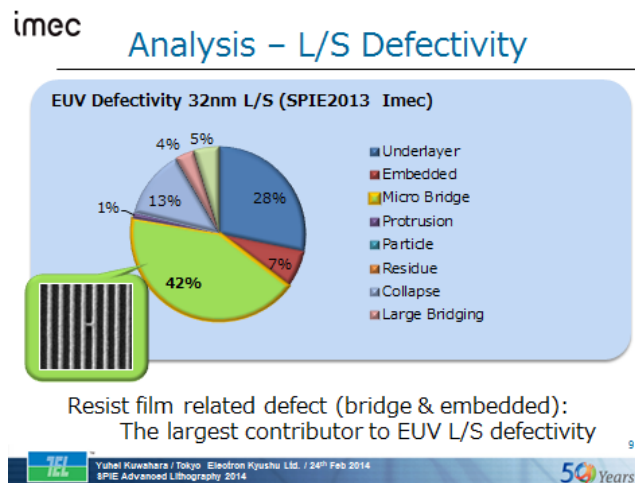
Introduction review from 2014 SPIE

• Defect reduction for L/S pattern

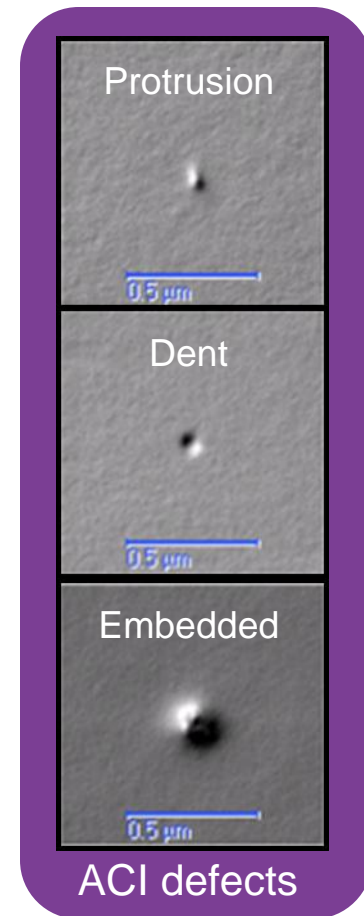
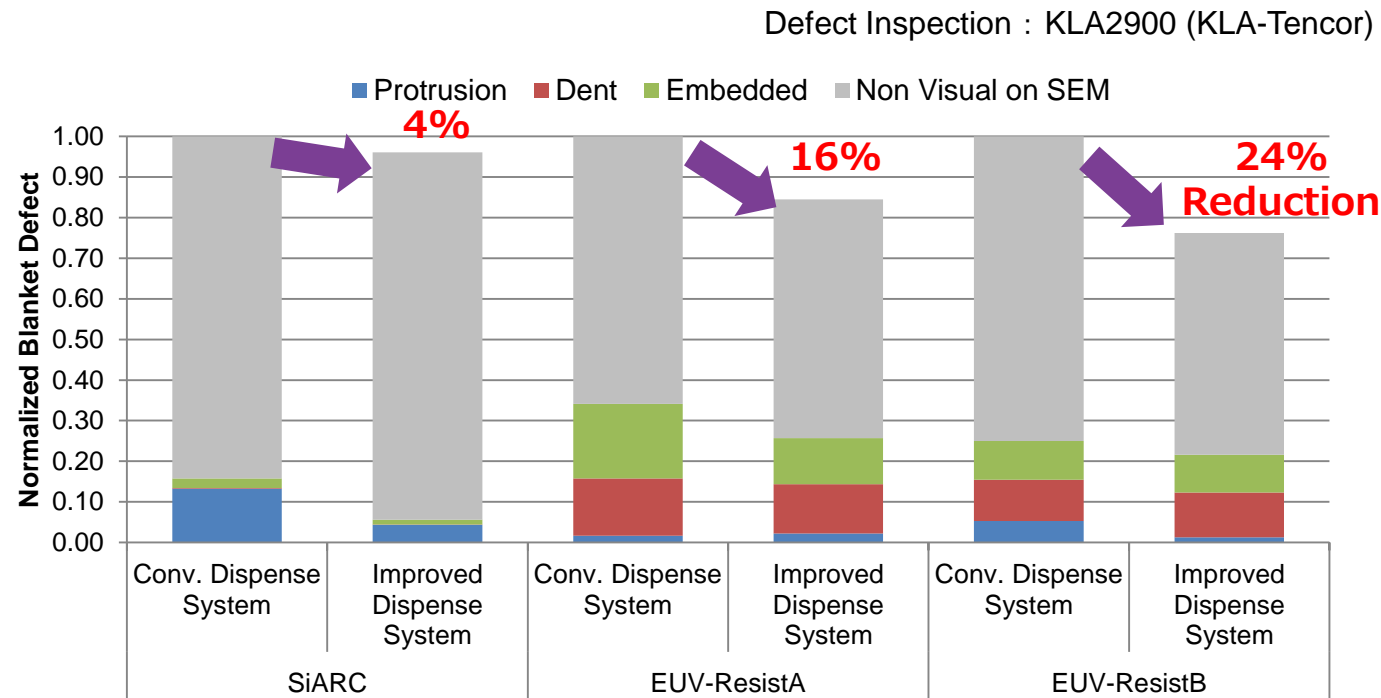
- Coating related defects are the largest contributor. Improved resist dispense system is implemented to reduce these defects.

• Pattern collapse mitigation

- New rinse material improved process margin even on sub-20nm HP. Further trial for new material is done and checked resist compatibility.



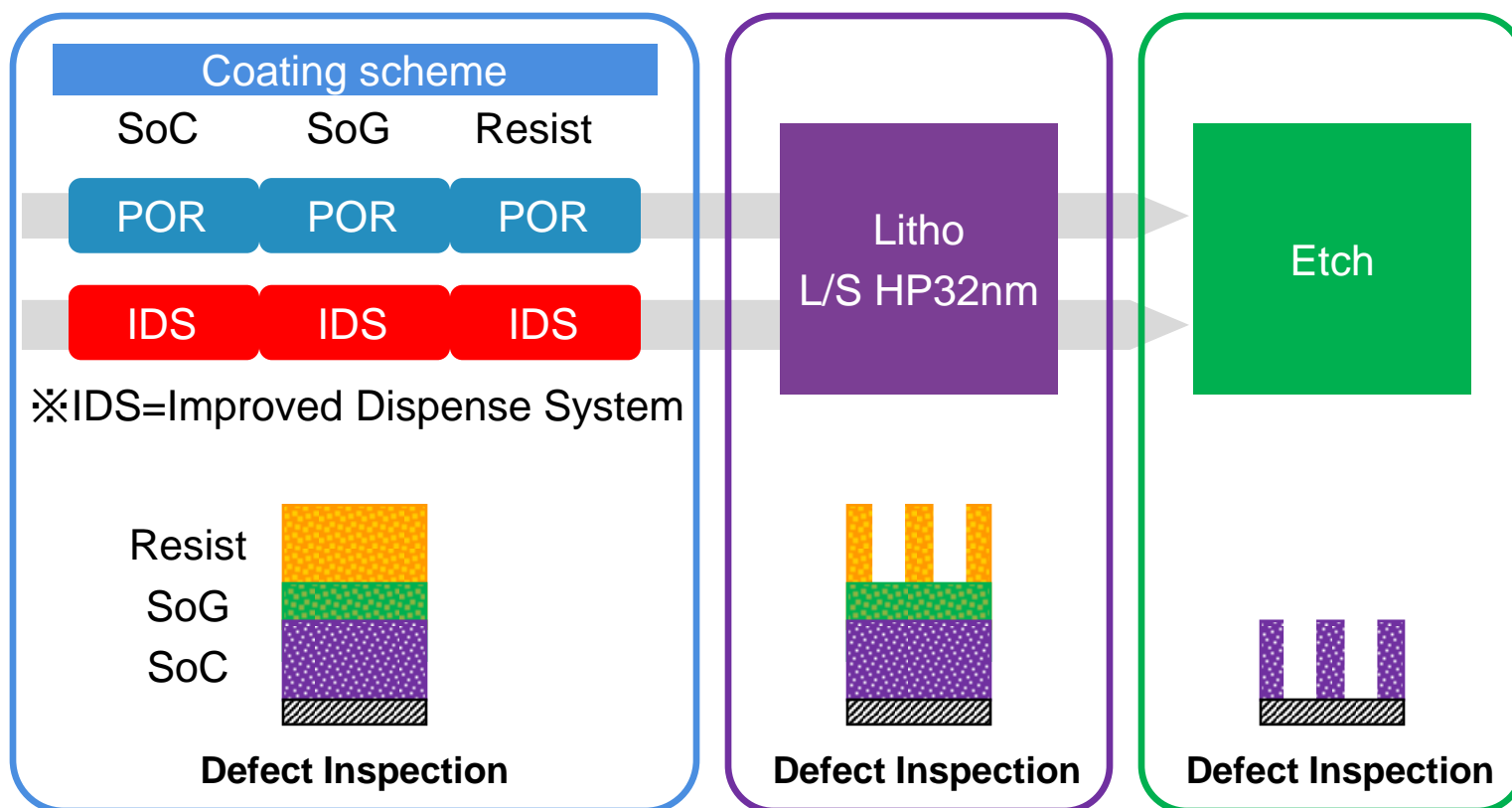
Blanket Coating Defect Reduction by Improved Dispense System at TEL in-house



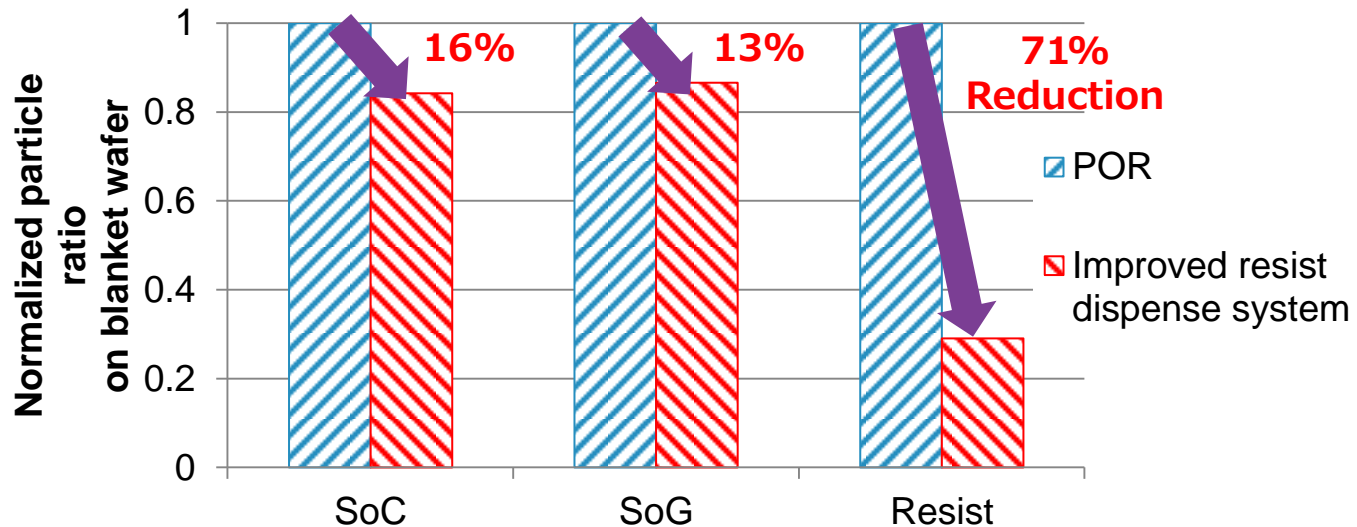
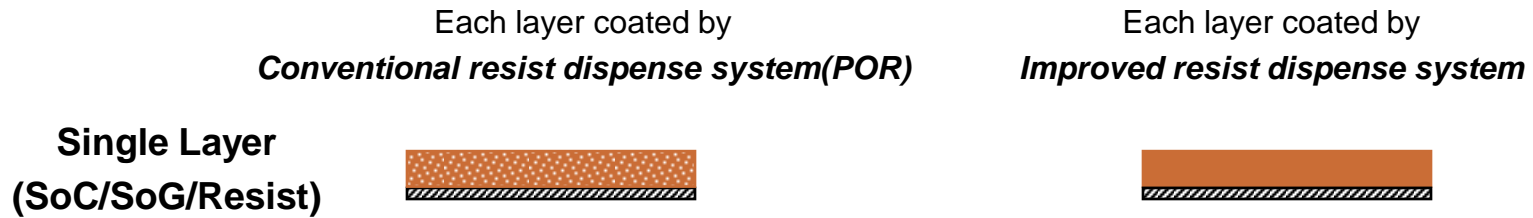
- Improved resist dispense system can reduce blanket coating defect for several materials

Experiment for Patterning

- Compare POR and Improved dispense system for each layer at post litho inspection.
- Post etch defectivity is also inspected.



Blanket Coating Defect Reduction by Improved Dispense System at imec

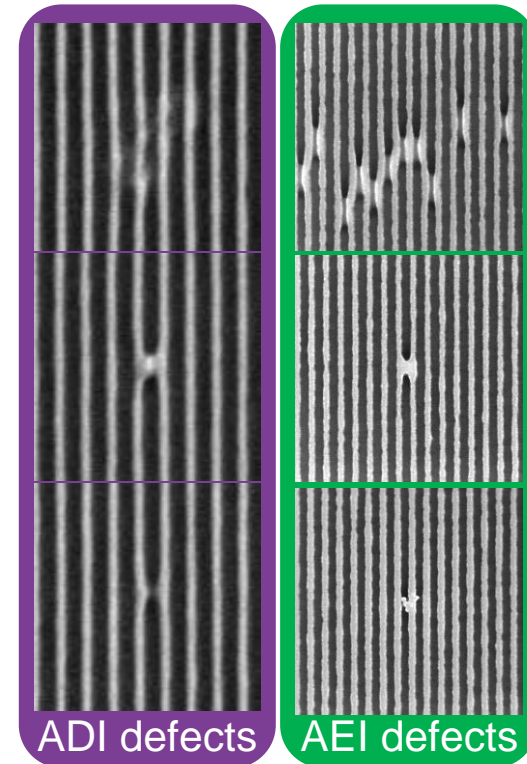
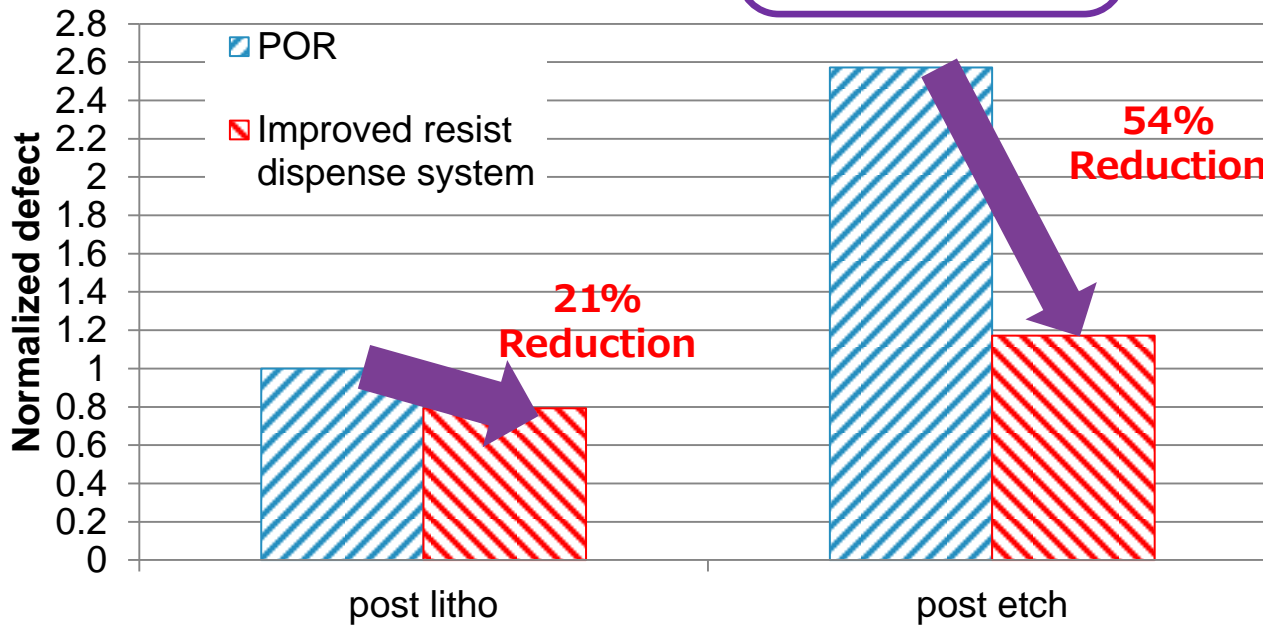
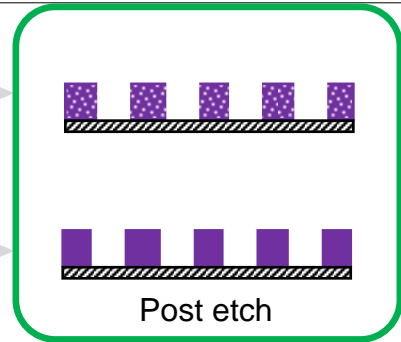
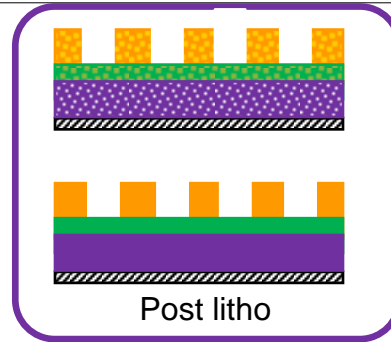


- Improved resist dispense system can reduce blanket coating defect for each materials.

Experiment Result, Post Litho and Etch Defectivity

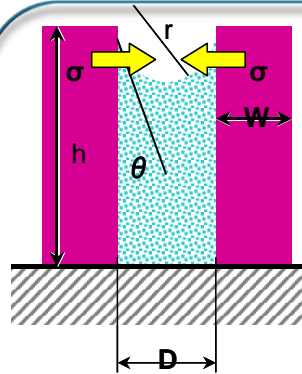
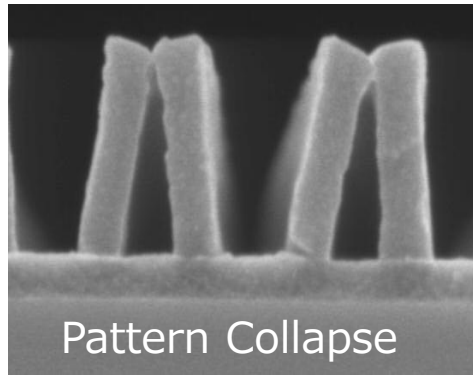
All layer coated by
Conventional resist dispense system
(POR)

Improved resist dispense system



- **Benefit of coating particle reduction, improves post etch density dramatically.**

Pattern Collapse Mitigation



$$\sigma = 6\gamma \cos\theta / D \times (h/W)^2$$

σ ; The maximum stress which works to pattern

γ ; Surface tension of rinse θ ; Contact angle

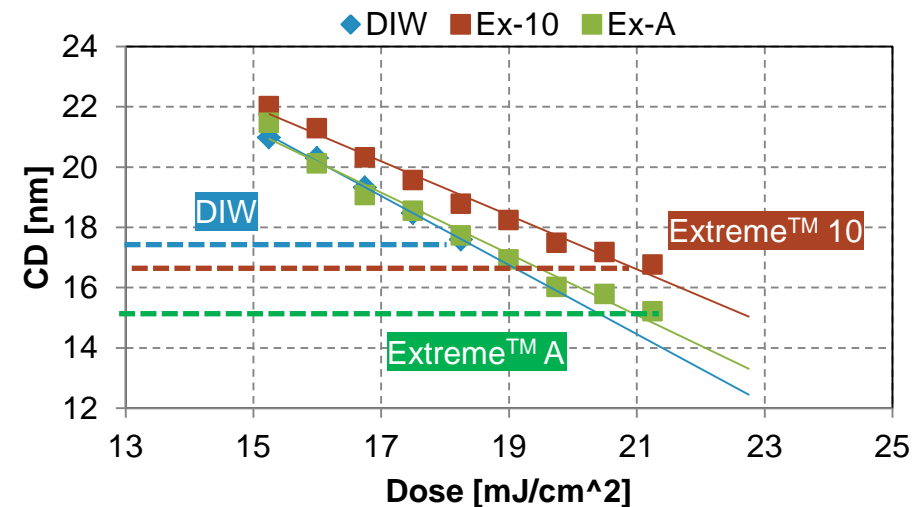
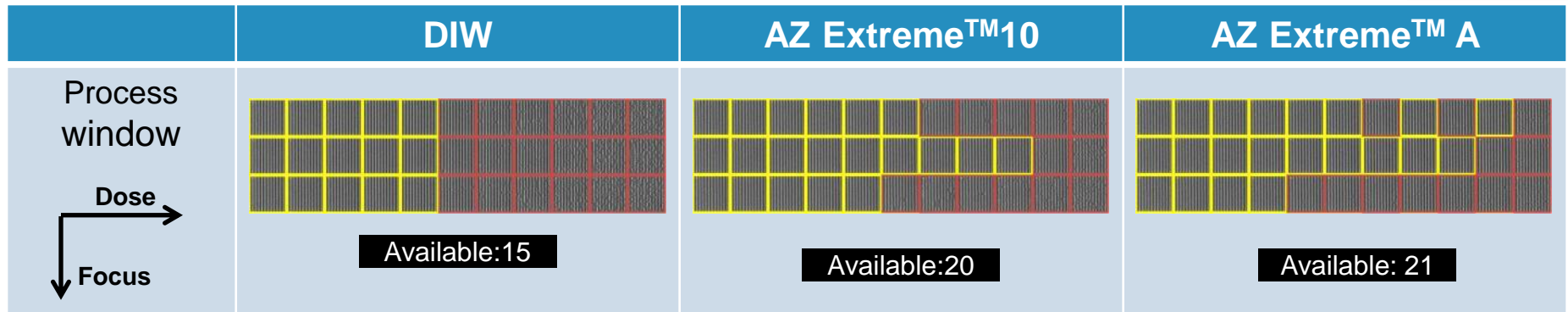
h ; Height of pattern D ; Space of pattern

W ; Width of pattern h/W ; Aspect ratio

N. Namatsu *et al.*, *Appl. Phys. Lett.* 66(20), pp.2655-2657, (1995)

- **Approach to tackle this challenge**
 - ‘ $\gamma \cos\theta$ ’-reduction by introducing a New ‘FIRM™ Material’
- **Check the resist compatibility below 20nm pattern**

Result on 20nmHP of Resist B



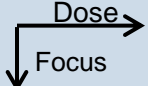
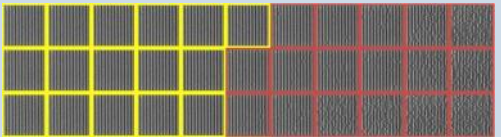
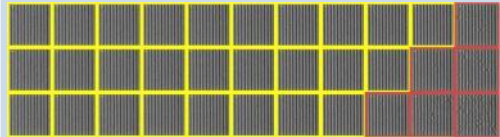
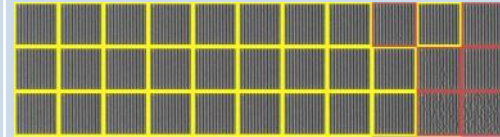
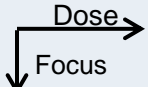
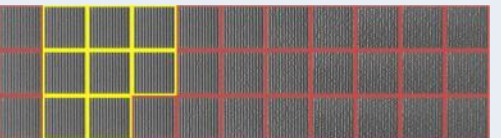
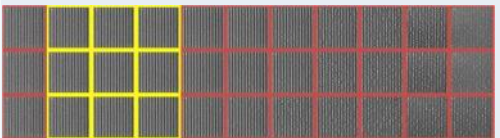
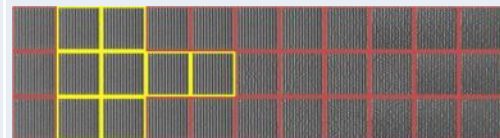
Yellow square: No collapses
Red square: Unavailable pattern (collapse, no resolution, melt)



	smallest CD [nm]	Δ CD from DIW [nm]	LWR [nm]
DIW	17.59	-	7.08
AZ Extreme™10	16.76	0.99	6.75
AZ Extreme™ A	15.21	-0.18	7.22

- **Extreme™ A has**
 - **best smallest CD without pattern collapse.**
 - **Smaller CD change from DIW process than Extreme™ 10**

※AZ Extreme™ is a Trade mark of AZ Electronic Materials, A subsidiary of Merck KGaA, Darmstadt, Germany.

Resist Compatibility below 20nm Pattern

Half pitch / Resist	DIW	AZ Extreme™10	AZ Extreme™ A
HP 18nm / Resist C 	 Available:16	 Available:27	 Available: 27
HP 17nm / Resist D 	 Available:8	 Available:9	 Available: 8

 No collapses
 Unavailable pattern (collapse, no resolution, melt)

- **Extreme™ A shows pattern collapse mitigation for**
 - Below 20nm pattern
 - Several resist materials

		smallest CD [nm]	Δ CD [nm]	LWR [nm]
HP 18nm / Resist C	DIW	16.71	-	6.90
	AZ Extreme™10	16.04	1.69	6.43
	AZ Extreme™ A	14.94	0.44	6.91
HP 17nm / Resist D	DIW	16.18	-	8.47
	AZ Extreme™10	17.64	1.22	7.98
	AZ Extreme™ A	15.19	0.1	8.22

Summary

- **Coating related defect reduction**

- Improved resist dispense system can reduce 21% coating related defect post litho inspection.
- Improved resist dispense system shows the effect for not only post litho but also post etch.
- Post etch defectivity is reduced more than 50% by using improved resist dispense system.

- **Pattern collapse mitigation**

- ExtremeTM A extend pattern collapse margin even on below 20nm pattern.
- ExtremeTM A indicate great compatibility with all imec POR materials.

Acknowledgement

- **The authors would like to extend their appreciation to**
 - Tokyo Electron Kyushu Ltd. SPE Process Technology department
 - Tokyo Electron Europe Ltd. service team
 - Tokyo Electron Miyagi Ltd. Product engineering & development department 2

imec

